Fiscal Year:	FY 2018	**Task Last Updated:**	FY 09/26/2018
PI Name:	Salas, Eduardo Ph.D.		
Project Title:	Evidence-based Metrics Toolkit for Measuring Safety and Efficiency in Human-Automation Systems--NNX15AR28G		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Space Human Factors Engineering		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	(1) **HARI**:Risk of Inadequate Design of Human and Automation/Robotic Integration		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	eduardo.salas@rice.edu	**Fax:**	FY
PI Organization Type:	UNIVERSITY	**Phone:**	713-348-3917
Organization Name:	Rice University		
PI Address 1:	Department of Psychology		
PI Address 2:	6100 Main Street MS25		
PI Web Page:			
City:	Houston	**State:**	TX
Zip Code:	77005	**Congressional District:**	7
Comments:	NOTE: Previous affiliation was University of Central Florida, until mid-2015		
Project Type:	GROUND	**Solicitation / Funding Source:**	2012 Crew Health NNJ12ZSA002N
Start Date:	08/01/2015	**End Date:**	06/30/2018
No. of Post Docs:	0	**No. of PhD Degrees:**	1
No. of PhD Candidates:	1	**No. of Master' Degrees:**	0
No. of Master's Candidates:		**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	4	**Monitoring Center:**	NASA ARC
Contact Monitor:	Gore, Brian	**Contact Phone:**	650.604.2542
Contact Email:	brian.f.gore@nasa.gov		
Flight Program:			
Flight Assignment:	NOTE: End date change to 6/30/2018 per NSSC information and E. Connell/HRP (Ed., 5/3/18) NOTE: End date change to 4/30/2018 per NSSC information (Ed., 8/9/17) NOTE: Element change to Human Factors & Behavioral Performance; previously Space Human Factors & Habitability (Ed., 1/19/17)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):			
Grant/Contract No.:	NNX15AR28G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	NOTE: Continuation of "Evidence-based Metrics Toolkit for Measuring Safety and Efficiency in Human-Automation Systems," grant #NNX13AO51G with Principal Investigator (PI) Eduardo Salas, Ph.D., due to PI move in mid-2015 to Rice University from University of Central Florida. Specific aims of this proposal are threefold: (1) develop a framework for human-systems integration requirements, (2) identify and develop a metrics criteria in which safety and efficiency can be characterized in human-automation teams, and (3) design, develop, and validate a theoretically-driven, empirically-based metrics toolkit that characterizes the safety and efficiency of human automation interactions. This proposal meets NASA goals and objectives by mitigating the risk of inadequate design of human and automation/robotic integration through the development of safety and efficiency metrics for human-automation systems. The proposal is divided into three primary phases. Phase 1 will consist of synthesizing and translating findings from the extant literature relevant to human automation/robotic integration. The result of this effort will be the development of objective metrics generalizable to individual and team levels that characterize the safety and efficiency of a human automation interaction. The final outcome of Phase 1 will be the development of a human automation interaction metrics (HAIM) toolkit. Phase 2 will involve in-depth preparation for scientifically sound experiments. Phase 2 ensures adequate time and methodology for meaningful outcomes for Phase 3. The central outcome of Phase 2 will be the final development of the experimental testbed and experimental protocol. Phase 3 will involve preparation for, and execution of, experiments. This will include the design and execution of a set of multi-level empirical studies aimed at validating the metrics toolkit. The validation studies will focus on testing different aspects of human automation interaction (e.g., levels of automation, task complexity, and the number and configuration of system operators). The outcome of the proposed effort will provide NASA a set of evidence-based, empirically-validated guidelines and a measurement toolkit for mitigating the risk of inadequate design of human and automation/robotic integration as it pertains to the development of safety and efficiency metrics for human automation systems.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	
Task Progress:	Phase 1: The purpose of this phase was to synthesize and translate findings from the extant literature relevant to human automation/robotic integration in order to determine specific metrics that characterize the safety and efficiency of a human-automation interaction. The final outcome of Phase 1 was the development of the content for human automation interaction metrics (HAIM) toolkit. This content was then packaged inside an automated online tool that went a step beyond our original aim for this project by providing designers with a tool that not only contained content, but also provided information, tips, and advice for how to apply this content to their own measurement situations. Phase 2: The original goal for this second phase was to complete in-depth preparation for scientifically sound experiments. This detailed preparation time in phase 2 was meant to ensure adequate time and methodology for meaningful outcomes for Phase 3. The intended outcome of Phase 2 was be the final development of the experimental testbed and experimental protocol. However, as more was learned throughout phase 1 about Human-Automation measurement and as the toolkit development was progressing, it was determined that Phase 2 should be adjusted to better meet the goals of the overall project. Therefore, Phase 2 was adjusted to be preparation for Subject Matter Expert (SME) interviews and iterative usability evaluations of the HAIM Toolkit instead of validation experiments to test the theoretical framework. This proved to be a very fruitful decision as the SME interviews provided valuable feedback and data that was able to be incorporated into the final design of the toolkit. Phase 3: Preparation for and execution of, experiments. This final phase of the project was originally planned to include the design and execution of a set of multi-level empirical studies aimed at validating the theoretical framework and metrics toolkit. The focus of the validation studies was to be on testing different aspects of human automation interaction (e.g., levels of automation, task complexity, and the number and configuration of system operators). The intended outcome of the proposed effort was to provide NASA a set of evidence-based, empirically-validated guidelines and a measurement toolkit for mitigating the risk of inadequate design of human and automation/robotic integration as it pertains to the development of safety and efficiency metrics for human automation systems. Phase 3 was adjusted to focus on validation of the automated HAIM Toolkit through execution of usability evaluations by potential end users as this was deemed more valuable than the originally planned validation studies. The usability studies that were conducted were designed to evaluate both usability of the automated HAIM Toolkit as well as the value of the information that the toolkit provided. Multiple rounds of testing took place along with subsequent periods or toolkit redesign to incorporate feedback gleaned during the usability testing. The final outcome of this effort along with the research conducted in Phase 1 is a set of principles, guidelines, and tips for measurement that have been submitted to NASA in white papers and are in the process of being transformed into multiple manuscripts currently under preparation. Additionally, the final outcome of this phase is the development of the HAIM Toolkit, which is complete and will be delivered to NASA with the final report. Manuscripts in various stages: Hughes, A.M., Marlow, S.L., Hancock, G.M., Oglesby, J.M., Stowers, K. & Salas, E. (Under Revision). Physiological assessment of workload: A meta-analysis. Human Factors Stowers, K., Iwig, C., Salas, E. (In preparation). Measurement in the Second Machine Age: Considerations for Future Human-Machine Systems. To be submitted to Human Factors. Stowers, K., Sonesh, S., Iwig, C., Salas, E. (In preparation). Technology and Teams: The Impact of Technological Evolution on Team Performance. To be submitted to Group and Organization Management. Stowers, K., Sonesh, S.C., Iwig, C., Salas, E. (In preparation.) Capturing Human Machine System Safety in Spaceflight. To be submitted to Aerospace Medicine and Human Performance.
Bibliography Type:	Description: (Last Updated: 06/10/2021)
Articles in Peer-reviewed Journals	Hughes AM, Hancock GM, Marlow SL, Stowers K, Salas E. "Cardiac measures of cognitive workload: A meta-analysis." Human Factors. 2019 May;61(3):393-414. Epub 2019 Mar 1. https:// ; PubMed PMID: 30822151 , May-2019